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F I N A L R E P O R T

TIME DELAY AND BALLAST SYSTEM

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DELAY AND
FINAL REPORT

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Introduction

Pillow balloons which are hydrogen filled plastic envelopes are used extensively for carrying leaflets. Unlike the J-100 neoprene balloons, these do not continue rising until they burst. Because the plastic skin will not stretch to accommodate expansion of the hydrogen during ascent, the lowest corner of the envelope contains a bleed hole to let excess gas escape. As a consequence their flight path levels-off after a time and continues horizontally until gradual diffusion of the hydrogen from the balloon brings it again to earth. To release the leaflets so they will disperse over a specific target somewhere along the flight path, a time delay and ballast system is used. The object of this task was to investigate and design devices which would overcome certain limitations in the system currently in use.

Requirements

In the present system dry ice is used for both the delay and the release system. Leaflets are contained in an open box hung beneath the balloon. The box is supported at a pivot below its center of gravity but a bag of dry ice hung from the bottom of the box places the center of gravity of the system, box plus bag, below the pivot. As the dry ice sublimes, the center of gravity of the system moves upward, and as it passes the pivot point, the box inverts dropping the leaflets. The rate of sublimation and therefore the mass of dry ice which must be used for a given delay time depends on atmospheric conditions and may only be estimated. The resulting error in delay time, the loss of ballast during ascent, and the difficulty of procurement and storage of dry ice at the launching site are the chief objections to this method. In addition to obviating these limitations in the system to be developed under this task, further target specifications were:

a) Delay time 3 to 12 hours

b) Delay time error ± 2.5 to 5%

c) Ballast weight 1 pound

d) Delay weight 1/2 pound maximum

e) Capable of dropping the 1 pound of ballast in not less than 10 increments over a 10 hour period

f) Weight of the system (less ballast) not more than 1/2 pound, including the weight of the payload container

g) System to be stable and operative at low temperatures and high wind speeds

h) Low production cost in keeping with the intended use of the system.

Preliminary Investigations

Initially, general consideration was given to a wide variety of mechanisms and modes of operation. Various solids and liquids were investigated for use in sand and water clock type delays. Silicone delays, which had been under development on another task were considered a good possibility. Mechanisms with an escapement and balance wheel were regarded as highly desirable because of their insensitivity to environmental conditions but at first thought these were considered too expensive.

Liquids

Earlier attempts to use liquids in this application were reviewed. Delays may be made in many ways which employ the unique properties of liquids, viscosity, evaporation, capillary action, and so on, but most arrangements are strongly dependent on ambient conditions.

Sand

Sand clock devices were at first thought to be suitable for the delay and some experimental setups were made and tested. The mass flow rate was too high with sand of about the grain size used in hourglasses. With finer sand a smaller orifice could be used which resulted in a lower mass flow rate but the minimum flow obtained used about six pounds of sand for the required twelve hours. With still finer sand or smaller orifices the flow became erratic or stopped altogether. Some consideration was given to lighter materials which could be granulated to flow like sand. However, the advantage of the low cost of sand would no longer be obtained. Meanwhile, other delays in development showed promise so this approach was abandoned.

Silicone Extrusion

The first silicone delay was adapted from one which had been under development on another task. The viscous silicone resin was contained in a cylinder and extruded through a small orifice by a spring driven piston. Although the viscosity of silicone materials changes less with changes in temperature than most other materials of like consistency, some compensation for temperature would be required. Attempts were made to use the varying rates of expansion of metals with temperature to change the orifice size automatically to provide this compensation. However a quicker and less costly development was needed.

Silicone Damping

Another variety of silicone delay which was investigated consisted of a paddle wheel enclosed in a cylinder filled with silicone gum. The drive shaft for the paddle wheel extended through the ends of the cylinder so that it could be externally driven. This system was to use the payload weight suspended by strings around spools on the drive shaft as the driving torque on the paddle wheel. Rotating in the silicone gum the paddle wheel was subject to viscous damping forces which retarded its angular velocity. As with the silicone extrusion devices some change of viscosity with temperature was experienced. Compensation for this in the paddle wheel delay was to be accomplished by changing the effective paddle area by means of bi-metals. Before any work was accomplished along these lines, however, the decision was made to concentrate efforts on the mechanical timers which had been under development simultaneously.

Mechanical Timers

Mechanical timers were investigated along two lines: first, to find a sufficiently inexpensive commercial mechanism which would satisfy the requirements, or second, to find a suitable mechanism the essential parts of which could be produced inexpensively. For the second approach several designs were made copying the operating principle found in a waffle iron timer. This timer was chosen because of its rugged design and the possibility of making its parts by injection molding. This did not become economically feasible.

Following the first line of attack mentioned above, six different brands of household intermittent mechanical timers were obtained for evaluation. It was found that the mechanisms contained in these timers were produced by one of three manufacturers, namely, U.S. Time Corporation, Westclox Corporation or King Seeley Corporation. The latter company produced a mechanism that offered the most promise because of the outward extension of both ends of the drive shaft through the frame. This permitted the use of the payload as the driving force of the timer. By mounting spools on the ends of the shaft, the time elapsed from the launching of the balloon to the release of the payload could be predicted depending on the amount of line wound on the spools. The spools would be unwound as the escapement of the timer mechanism permitted the drive shaft to turn at a constant speed, paying out the line while the balloon was in flight.

The mechanical timers were tested to insure continuous functioning under field conditions. A group of modified timers was subjected to -60°F for 8 hours and continued to function for the duration of the motivating force which was approximately 6 hours. The units were then removed from the -60°F test cabinet and the driving force re-set. The units continued to function in defiance of a large build-up of frost and ice due to condensation on the sub-zero units when exposed to room temperature. No time change was detected in this test. However, a time loss of 10 per cent was recorded while the units were in the cabinet at -60°F.

Mechanical Release Systems

After selection of a mechanical timer, increased efforts were placed on the ballast and payload release system. One approach to ballast release utilized the payload as the releasing agent. Several prototypes were constructed and finally a rectangular shaped plastic box was designed for containing the ballast. One side of the box was a sliding door which allowed the ballast to fall out as the door was lowered. The door was directly connected to the payload so as not to interfere with the timer. For convenience in loading, the box was divided into 12 compartments. The dimensions of the box and the sliding door were arranged so that ballast would begin dropping after one hour. By the end of the second hour all the ballast in the first compartment would have been released and the second compartment would begin to drop ballast, and so on for a total of 13 hours. The compartments had the additional advantage of preventing the total weight of ballast from jamming the sliding door at the bottom.

The unit was tested in the field, but due to an extreme wind velocity, the system was shaken violently, resulting in a sudden loss of ballast and some snapping of the system's lines.

A need was felt, therefore, for enclosing the system in order to combat any climatic disturbance such as the one encountered in the test. A more compact unit was designed with the timer and ballast release mechanisms contained in one housing. The payload is hung from a spool of ribbon on the timer drive shaft and provides the motivating force. Strips of lead foil, 1/2" x 3" x 0.005", which have been wrapped between successive layers of ribbon, fall out and flutter away as the spool is unwound. When the spool is completely unwound, the ribbon with the payload attached also falls off. Dispersion of the payload would be accomplished by containing it in a "carrier" such as developed in Task 1210-C-22.